(2/4) Research in Medicine, Rational Design

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How Alzheimer's and Diabetes Work at the Nano-Scale

Last week, we reviewed how rational drug design has the potential to lower drug prices by cutting the costs of failure in pharmaceutical experiments and development.

Today, we'll talk about the research that makes drug design possible. First, scientists must learn the language of the body, which at its most fundamental level, is the same as the language of the solar system: **physics**.

It might not seem that way because our bodies feel so unpredictable, but there is a sublime order underneath the chaos: how molecules talk to each other, what turns certain genes on and off, why some cells become blood cells and others platelets. Why some people get diseases and others don't.

The drugs that we use to treat disease also operate under the same laws of physics. After all, how else would we be able to mass produce medicines like insulin or Tylenol if there wasn't some sort of predictability?

Tying together the human body and drug reactions under the language of physics allows us to use computer simulations for faster, more effective drug designs.

Bringing It All Together: Nanobiotechnology

"Biology is nanotechnology that works," says Tom Knight, named the godfather of synthetic biology at MIT.

Known as the engineer's biology, synthetic biology "focuses on practical outputs," says Dr. Jeffrey Way with the Wyss Institute. It uses the same tools as biology; tools that were shaped over millions of years of natural evolution. For example, instead of harvesting the anti-malarial drug, Artemisinin, from the plant *Artemisia annua*, synthetic biologists use genetically modified yeast to ferment the drug in a lab, freeing supply from crop fluctuations.

In order to practice synthetic biology, we reduce the human body down to its most fundamental level; from groups of organs to bunches of molecules, proteins, and peptides, eventually down to the atomic realm of pinball and electromagnetic physics: a field called **nanobiotechnology**.

At the Micro-scale: Alzheimer's Disease and Diabetes

Many diseases occur on the macromolecule or protein level, which we can observe easily through microscopes. For example, we have known for the last dozen years that Alzheimer's disease and diabetes share in common large, sticky protein plaques called **amyloid** which collect in the brain and pancreas. An individual plaque is made of many proteins, which are made of even smaller peptides, which themselves are just a handful of atoms. To see at this nano-scale, you need a special electron microscope.

Into the Nano-scale: Self-Assembling Peptides

Dr. Ehud Gazit, a leader in the field of nanobiotechnology, has been studying how and why these amyloid plaques form for over 15 years. His research shows that these proteins self-assemble because it is energetically advantageous, meaning that they form naturally and on their own. Why is it advantageous? And how can we energetically motivate these plaques *not* to form?

To better understand **self-assembly**, imagine as if the king-sized bed that you ordered from IKEA has a new feature: automatic furniture assembly. You open the box and the bed just puts itself together. That's great, as long as one of your children doesn't peek inside and accidentally open it in the narrow hallway entrance of your home. Then you're stuck with a giant king-sized bed stopping anyone from entering or leaving, wondering if it's even worth your time to take it apart, or if you just want to start sleeping in the entryway.

Self-assembly isn't all bad, though. Let's take a look at **guanine**, one of the four peptides that encode our DNA. It also has a tendency to self-assemble. Imagine a primordial goop where suddenly guanine self-assembles and meets other characters of our DNA molecule, bumbling around until the primary building blocks meet in just the right orientation. Fast forward several million years and we have humans. It's not only in human DNA that guanine self-assembles, the process is also responsible for the beautiful and vivid color changes in the skin of a chameleon.

As we better understand self-assembly, disease, and drug interactions through the languages of biology and physics, we can begin to merge these two fields. For example, we can now create moulds for nanoscale semiconductor wires using drinking-straw-shaped amyloid nanotubes that self-assemble. Cool, huh?

Up Next Week: Technology in Medicine

Learn how scientists removed the side effects of a billion dollar drug using **rational drug design.**

What is Compassionate Technologies?

Each Sunday we deliver to your doorstep an inspirational and educational piece describing a certain trend in technology and business.

We go from small to large throughout the year. This month focuses on Drug Design in Medicine, progressing up to topics in robotics, artificial intelligence, environmental and then space technologies.

Each month has four parts:

1st Sunday: Trends
2nd Sunday: Research
3rd Sunday: Technology
4th Sunday: Business

To keep our doors open, fund interviews with top scientists and industry players, and to continue hosting local events, we charge $150 per year for 52 print weeklies.

While we're getting started, I'm doing free deliveries in my neighborhood for the month of June. Please enjoy and consider joining me on this journey!

Kindly yours,

Olivia Jeffers

Thoughts?

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"From a small seed a mighty trunk may grow." - Aeschylus, Greek Poet (525-456BC)