1. **Table summarizing stent development. Because of personal interest, focus was put on the materials, and their effects, used for coronary artery stents.**

YEAR	INNOVATION	SOURCE
1986	First Intracoronary Stent	Kempczinski, R. (1987). *Intravascular stents to prevent occlusion and restenosis after transluminal angioplasty.* Journal of Vascular Surgery, 6(5), p.533.
1989	Balloon-expandable Intracoronary Stent	Palmaz, J., Sibbitt, R., Reuter, S., Tio, F. and Rice, W. (1985). *Expandable intraluminal graft: a preliminary study. Work in progress*. Radiology, 156(1), pp.73-77.
1996	Polymer-loaded Stent	van der Giessen, W., Lincoff, A., Schwartz, R., van Beusekom, H., Serruys, P., Holmes, D., Ellis, S. and Topol, E. (1996). *Marked Inflammatory Sequelae to Implantation of Biodegradable and Nonbiodegradable Polymers in Porcine Coronary Arteries*. Circulation, 94(7), pp.1690-1697.
1998	Heparin-coated Stent	Serruys, P., van Hout, B., Bonnier, H., Legrand, V., Garcia, E., Macaya, C., Sousa, E., van der Giessen, W., Colombo, A., Seabra-Gomes, R., Kiemeneij, F., Ruygrok, P., Ormiston, J., Emanuelsson, H., Fajadet, J., Haude, M., Klugmann, S. and Morel, M. (1998). *Randomised comparison of implantation of heparin-coated stents with balloon angioplasty in selected patients with coronary artery disease (Benestent II)*. The Lancet, 352(9129), pp.673-681.
2002	Cypher Stent	Sabate, M. (2005). *Randomized Comparison of Sirolimus-Eluting Stent Versus Standard Stent for Percutaneous Coronary Revascularization in Diabetic Patients: The Diabetes and Sirolimus-Eluting Stent (DIABETES) Trial*. Circulation, 112(14), pp.2175-2183.
2002	Thinner Stents	Briguori, C.; Sarais, C.; Pagnotta, P.; Liistro, F.; Montorfano, M.; Chieffo, A.; Sgura, F.; Corvaja, N.; Albiero, R.; Stankovic, G.; et al. *In-stent restenosis in small coronary arteries: Impact of strut thickness*. J. Am. Coll. Cardiol. 2002, 40, 403–409.

2003	Thinner Stents	Pache, J., Kastrati, A. and Mehilli, J. (2003). *Intracoronary stenting and angiographic results: strut thickness effect on restenosis outcome (ISAR-STEREO-2) trial*. ACC Current Journal Review, 12(4), p.66.
2003	Alloy for Stents	Kereiakes, D., Cox, D. and Hermiller, J. (2003). *Usefulness of a cobalt chromium coronary stent alloy*. ACC Current Journal Review, 12(6), p.50.
2005	Carbon ion-implanted Stent	Kim, Y., Lee, C., Hong, M., Park, S., Tahk, S., Yang, J., Saito, S., Santoso, T., Quan, L., Ge, J., Weissman, N., Lansky, A., Mintz, G. and Park, S. (2005). *Randomized comparison of carbon ion–implanted stent versus bare metal stent in coronary artery disease: The Asian Pacific Multicenter Arthos Stent Study (PASS) trial*. American Heart Journal, 149(2), pp.336-341.
2010	Polymer-free Stent	Tada, N., Virmani, R., Grant, G., Bartlett, L., Black, A., Clavijo, C., Christians, U., Betts, R., Savage, D., Su, S., Shulze, J. and Kar, S. (2010). *Polymer-Free Biolimus A9-Coated Stent Demonstrates More Sustained Intimal Inhibition, Improved Healing, and Reduced Inflammation Compared with a Polymer-Coated Sirolimus-Eluting Cypher Stent in a Porcine Model.* Circulation: Cardiovascular Interventions, 3(2), pp.174-183.
2012	Biodegradable polymer Stent	Stefanini, G., Byrne, R., Serruys, P., de Waha, A., Meier, B., Massberg, S., Juni, P., Schomig, A., Windecker, S. and Kastrati, A. (2012). *Biodegradable polymer drug-eluting stents reduce the risk of stent thrombosis at 4 years in patients undergoing percutaneous coronary intervention: a pooled analysis of individual patient data from the ISAR-TEST 3, ISAR-TEST 4, and LEADERS randomized trials*. European Heart Journal, 33(10), pp.1214-1222.

2. **Table summarizing some of the undesirable outcomes or risk associated with stents.**

UNDESIRABLE OUTCOME	SOURCE
Infection	Kempczinski, R. (1987). *Intravascular stents to prevent occlusion and restenosis after transluminal angioplasty.* Journal of Vascular Surgery, 6(5), p.533.
Delayed Restenosis	Virmani, R. (2002). *Mechanism of Late In-Stent Restenosis After Implantation of a Paclitaxel Derivate-Eluting Polymer Stent System in Humans.* Circulation, 106(21), pp.2649-2651.
Stent Thrombosis	Daemen, J., Wenaweser, P., Tsuchida, K., Abrecht, L., Vaina, S., Morger, C., Kukreja, N., Jüni, P., Sianos, G., Hellige, G., van Domburg, R., Hess, O., Boersma, E., Meier, B., Windecker, S. and Serruys, P. (2007). *Early and late coronary stent thrombosis of sirolimus-eluting and paclitaxel-eluting stents in routine clinical practice: data from a large two-institutional cohort study*. The Lancet, 369(9562), pp.667-678.
Late Thrombosis	Otsuka, F., Nakano, M., Yazdani, S., Ladich, E., Kolodgie, F. and Virmani, R. (2011). *Pathology of First-generation Drug-eluting Stents in Humans*. Interventional Cardiology Review, 6(1), p.28.
Allergic Reaction	Koster, R., Vieluf, D. and Sommerauer, M. (2001). *Nickel and molybdenum contact allergies in patients with coronary in-stent restenosis.* ACC Current Journal Review, 10(3), p.62.
Medication Side effects	Park, S., Lee, C., Kim, H., Lee, N., Nah, D., Hong, M., Kim, J. and Park, S. (2000). *Effects of cilostazol on angiographic restenosis after coronary stent placement*. The American Journal of Cardiology, 86(5), pp.499-503.

3. **"Negative" finding regarding the use of stents in patients with coronary artery disease:**

There is no empirical evidence of the effectiveness of stents, specially when treating angina. Even after receiving their first stent and reporting and immediate pain relief, patients come back with chest pains. Because stents were so revolutionary in the field of interventional cardiology,

many doctors think of them as the go-to approach against coronary artery diseases. This has led to the public believing stents are the only solution, when in reality their efficiency hasn't be proven. Moreover, this fact can alter how patients think about the procedure and the results: they may report relief because stents are supposed to relief pain. Current studies are investigating this placebo effect with un-stented and medicated control groups and will determine the efficiency of stents.

At the same time, new studies have shown that stents do not prevent heart attacks or deaths from heart disease, and that medications can be just as effective as stenting or coronary bypass in preventing heart attacks. This is due to the fact that even if an artery is unclogged with a stent, other clogs could happen independently up or downstream of the stent, or even in the same part of the artery where the stent was placed. Now that the fields of pharmacokinetics and pharmacodynamics have advanced dramatically and more precise drugs and delivery tools are available to doctors, medications for treating coronary artery diseases might be a better option than stenting.

References:

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- Kolata, G. (2018). 'Unbelievable': Heart Stents Fail to Ease Chest Pain. [online] Nytimes.com. Available at: https://www.nytimes.com/2017/11/02/health/heart-disease-stents.html [Accessed 22 Apr. 2018]

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4. **Estimated wing size for different animals based on the Canada goose.**

Weight of Canada goose: **3.9 kg** Cruising speed = 25 m/s

Wingspan of Canada goose: 127 cm, Wing chord of goose: 39 cm Wing area = 0.4953 m^2

Wing-loading of Canada goose: W/A = **52.18 N/m^2**

Weight of *Argentavis Magnificens*: **70 kg** Wing size = **8.8 m^2**

Weight of male African Bull Elephant: **4700 kg** Wing size = **596 m^2**

If the we are assuming the wing-loading is the same for both Canada goose and male elephant, then their cruise velocities will also be the same: (goose = 1, elephant = 2, Wl = wing loading)

$$\frac{F1}{F2} = \frac{Cl_{ma} * 0.5 * \rho * V1^2 * A1}{Cl_{max} * 0.5 * \rho * V2^2 * A2} = \frac{m1 * g}{m2 * g} \Rightarrow V2^2 = V1^2 * \frac{m2}{m1} * \frac{A1}{A2} = V1^2 * \frac{Wl2}{Wl1} = V1^2$$

However, if we don't assume the same wing-loading but that the wing area scales with body size (A α L^2), and taking into account that m = $\rho * L^3$, then we can say that:

$$F2 = 0.5 * \rho\, Cl_{max} * V2^2 * L^2 = m2 * g \Rightarrow V2^2 = K * m2^{\frac{1}{3}} \Rightarrow V2 = \sqrt{V1^2 \left(\frac{m2}{m1}\right)^{\frac{1}{3}}} \approx \mathbf{80\ m/s}$$

References:

- Madge, Steve; Burn, Hilary (1988). Waterfowl: An Identification Guide to the Ducks, Geese, and Swans of the World. Boston: Houghton Mifflin. ISBN 0-395-46727-6.
- Laurson, Barry; Bekoff, Marc (1978). "Loxodonta africana". Mammalian Species. 92 (92): 1–8. doi:10.2307/3503889. JSTOR 3503889.Something
- Mittal, Rajat (2018); Biolocomotion [PowerPoint Slides]

5. **Terminal velocity for different falling objects**

OBJECT	MASS	PROJECTED AREA	TERMINAL VELOCITY
Dust Particle	124*E-9 g	7.068*E-10 m^2	0.0233 m/s
Pollen	247*E-9 g	6.361*E-9 m^2	0.1358 m/s
Rain Drop	70 mg	1.963*E-5 m^2	9.1822 m/s
Golf Ball	45.93 g	1.429*E-3 m^2	32.4105 m/s

Data

- Kinematic viscosity of Air: 14.88*E-6 m^2/s (at 18ºC, 1atm)
- Density of Air: 1.212 kg/m^3 (at 18ºC, 1atm)
- https://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html

$$Cd = \frac{24}{Re} * (1 + 0.173 * Re^{0.657}) + \frac{0.413}{1+1.63*10^{-4}*Re^{-1.09}}$$

- Wilson, K. (2006). Slurry transport using centrifugal pumps. Boston, MA: Springer Science+Business Media, Inc.

Dust

- Diameter = 30 um, Area = Pi*R^2
- Lanzerstorfer, C. (2017). Variations in the composition of house dust by particle size. Journal of Environmental Science and Health, Part A, 52(8), pp.770-777.

Pollen

- Diameter = 0.09 mm, Area = Pi*R^2
- Pleasants, J. M.; Hellmich, R. L.; Dively, G. P.; Sears, M. K.; Stanley-Horn, D. E.; Mattila, H. R.; Foster, J. E.; Clark, P.; Jones, G. D. (2001). "Corn pollen deposition on milkweeds in and near cornfields". Proceedings of the National Academy of Sciences of the United States of America. 98 (21): 11919–24.
- http://www.bio.net/mm/maize/1999-November/000599.html

Rain Drop

- Diameter = 0.5cm, Area = Pi*R^2
- Mass for 0.5cm drop: 70mg
- "Liquid-Water Precipitation." *New Book of Popular Science, Deluxe Library ed. vol. 2*. Danbury, CT: Grolier, 1998: 167.

Golf Ball

- Diameter = 42.67mm, Area = Pi*R^2
- https://www.usga.org/content/dam/usga/pdf/2015/2016%20Rules/2016-rulesofgolf-USGAfinal.pdf

MATLAB Code to calculate Terminal Velocity:

```
m = [
    124*10^(-12)
    247*10^(-12);
```

```
    70/1000000;
    45.93/1000];

A = [
    7.068*10^(-9);
    6.361*10^(-9);
    1.963*10^(-5);
    1.429*10^(-3)];

L = [
    30/1000000;
    0.09/1000;
    0.5/100;
    42.67/1000];

v = 14.88*10^(-6);
g = 9.81;
rho = 1.212;

Re =@(u) u.*L/v;

Cd =@(Re) 24./Re.*(1+0.173.*(Re).^0.657)
+0.413./(1+1.63.*(10)^(-4).*(Re).^(-1.09));

U =@(Cd)sqrt(2.*m*g./(rho.*A.*Cd));

fsolve(@(u) u - U(Cd(Re(u))),[10 10 10 10]',
optimset('Display','off')')
```

ans =

0.0233

0.1358

9.1822

32.4105