

# Two Places At Once

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## An introduction to Virtual Reality



By

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## Introduction

More than any other type of IT-technology, the current kind of Virtual Reality promises to realise an ancient dream.

Where no one had really dreamt of the internet, the smartphone or even digital computer games before they were built and proved we always wanted unwittingly, Virtual Reality is in many ways the answer to a dream that humanity has had for many, many years.

From the religious ecstasy experienced in meditation and vision at the dawn of humanity to the artificial realities of hardened light of the holodeck on Star Trek, human beings have been fascinated by the idea of being two places at once.

We are divided beings. On one hand bound to flesh, on another liberated by spirit. Or in a more modern parlance: divided between organs collecting external sensory impressions and the brain that processes them and translates them into experience.

But the brain can even build these experiences independently of the sensory impressions. If we close our eyes and imagine, we can almost feel the sand between our toes from the beaches we visited as children, or taste a dish we have not had for decades. We call this day dreaming. When reality slides away and we feel a different, more real reality. Of course it's not actually more real, but while we dream *it is*.

In Virtual Reality we can dream with our eyes open. We can travel to other places, do fantastical things, play with the world in ways we have only done in our imagination. It sounds – especially to a sceptical Northerner – as hyperbole and marketing. But without fail, I have seen it happen. Everyone, from the most sceptical to the most technophile I have seen surrender themselves to the dream when they have tried even the most basic of today's technologies. A Samsung Gear VR handed around at a family gathering, only loaded with 360 still photos; a three year old child exploring the frozen landscapes of Greenland while sitting on my couch; walking around a painting in Quills by Oculus; drawing a bow and arrow in The Lab of the Vive; or standing in the middle of a refugee camp through the overwhelming movies and experiences created by UNICEF. We are two places at once.

The double reality of being here and there at once is so overwhelming and can be achieved with so relatively simple tools that what has been predicted so many times in the 20th century here in the beginning of the 21st is actually possible: we live in the time of Virtual Reality.

This provides new opportunities and challenges for everyone, not the least of which is for the developers who will build the tools to dream these dreams. In this book we at the Danish Institute for Game Development have collected an introduction to the research and best practice that is available at the moment.

The text of this book should provide the tools to navigate further into the development of and thoughts about Virtual Reality – perhaps through the extensive list of further literature, we have included. We have prioritised trying to find freely available sources where we can.

Finally, we have added a science fiction short story from 1935 – Pygmalion’s Spectacles – which as far as we can tell represents the first description of a technology similar to current consumer VR. It is fascinating how the author – Stanley Gaumann Weinbaum – accurately describes the promise and the challenges of VR design even today.

At Dania Games and the Danish Institute for Game Development, we have through the VR First-program from Crytek been given the opportunity to be at the forefront of delivering on that promise and tackle those challenges. We are very grateful for this.

It is our sincerest hope that this book will be the first step for many developers to begin working with Virtual Reality as well as for users to understand how this dreaming machine that seems poised to alter our world radically actually works.

We look forward to dreaming with you.

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## Basic Terminology in Virtual Reality Research

VR has been an object of research since the 1960s, but the overarching problem in applying all this research is that a lot of it is centred around specially built VR-machines – which do not necessarily resemble our current consumer technology enough to directly transfer the results – or it has been carried out to compare digital and analogue worlds, where the virtual worlds have been rendered on flat screens, such as a host of studies on the online world Second Life.

Nevertheless, a fair amount of useful conclusions have been drawn, which remain relevant to this day. In the 90s research into technologies very similar to ours also commenced. At the end of this book there is a list of some of the most important foundational research in this newer wave, but to make it easier to navigate in this, we will present some basic terms used throughout the field. These terms are based on the work of *Mel Slater*, who is probably the most influential single researcher in the field. The terms are marked with italics when they appear first below.

A VR-headset is called a *head-mounted display (HMD)* and it can be augmented with various *haptics*, physical sensory impression gadgets, for example a glove that provides the feeling of grasping something or a chair with a rumble function to simulate the feeling of riding in a car or on a train.

When you don an HMD, you are transported to a *virtual environment (VE)* while you still retain a feeling of being in your own body in the real physical world simultaneously. There is no agreed upon term for this feeling. In the VE, you have a certain *field of view (FOV)* which determines where you can look in the VE. For example, you can imagine being able to look around in 180 degrees in a VE, but being cut off by a dark wall behind you.

When you are in a VE, the VR-equipment can deliver a certain amount of *immersion*. Immersion is the sense of being surrounded by a different world. The feeling is the result of a series of sensory impressions, which are fed to the user. When they are working together, these sensory impressions achieve the effect that the body believes it is somewhere other than where it actually is physically, namely in the VE that is comprised of the sensory impressions.

Immersion can be measured through six different indicators, all of them structural or technical. They are:

- *Inclusive* – the degree to which the HMD is able to close sensory impressions from the actual world out (or keep the user closed in into the VE, if you prefer)
- *Extensive* – how many senses the VR-technology is able to manipulate
- *Surrounding* – how wide an FOV the VE has
- *Vivid* – how life-like the rendering achieved is, for example how high a resolution or how fast of a frame rate that can be achieved
- *Matching* – the degree to which the movements of the user in the physical world is mirrored in the VE
- *Plot* – the degree to which a narrative in the VE helps to convince the user that the VE is real

The main purpose of all of these points is to support the creation of *place illusion*, which is that the body believes the illusion that the VE presented by the HMD is a real world. The core in this is the quantity and quality of the sensory impressions, since the body treats these sensory impressions in the same way it treats all others. This means the body believes that they are real, if they are not cut off, jumping around because of latency in rendering or in any other way draws attention to their artificiality.

When the body has accepted another place as sufficiently real to conceptualise it as a place you could exist in, we move on to another core concept, namely *presence*. Presence is the feeling of bodily being in a VE, that is to say the feeling that you actually are in the world you have now accepted is real.

Presence is measured in two different ways in most research. Subjectively, where VR-users through systematic research are asked about their experience of presence, and objectively by observing users *in* VR and charting whether they act similarly in the VE to how they would act in the real world.

Presence and immersion are close cousins, since a certain degree of immersion is necessary to achieve presence. It is always a threat against presence when sensory immersion not simulated by the HMD is added. Research has shown, however, that some sensory information is integrated into the experience of the HMD, if there is no reason for the user to think that the sound is necessarily originating from outside the VE. For example, a user colliding with a wall in the real world which is not the VE will have her immersion broken, while someone talking off to the side, but not in the immediate FOV may just be assumed to be a part of the VE.

In addition to being closely related to immersion, presence is also next of kin to *cohesion*, which is the qualitative feeling of "realism" or "making sense" in the VE design. That's not to be confused with photorealism, but is a sense of the VE being predictable and understandable. For example, it's pretty weird in a photorealistic VE to be able to jump 20 meters up, but it would be natural in a VE based on Super Mario.

Cohesion is thus linked tightly with *behaviour*. Both the behaviour of objects, who must act in the way the VE-design seems to indicate, and the behaviour of characters who must act how you would expect characters to act in a similar situation. If you are playing a stealth-game, where you must sneak past guards, it is not essential for cohesion that the characters are able to convincingly discuss the metaphysics of Aristotle – but if they fail to notice you when you jump up and down in front of them, something is wrong.

The feeling of cohesion is very fragile and can be irrevocably destroyed with only a single misstep of behaviour. On the flip side, it can – since it builds on the human capacity for developing mental models rather than receiving sensory impressions – be realised with a very low degree of immersion and amplify the experience of presence enough to compensate effectively.

If the feeling of presence is achieved, this can be combined with a sense of *co-presence*. This is the feeling that other real persons are in the VE with you. These persons do not have to be actual persons, but experiments have shown that the possibility of meeting other humans in VE exists, users typically treat computer controlled agents as if they were human beings.

When all the different steps towards achieving presence work, you achieve *plausibility illusion*. This is the cognitive acceptance that you are somewhere else. You could put it this way: a successful place illusion makes you think a VE is real, while a successful plausibility illusion makes you accept that you yourself are in this VE, or that your virtual body is real.

In other words, you design an *HMD* – and possibly *haptics* – that renders a *VE*. If it contains an adequate amount of *immersion*-components – such as being *inclusive, extensive, surrounding, vivid, matching* and having a *plot* – the VE facilitates a *place illusion*, and the user thinks that the VE is real. If the VE is furthermore designed with high *cohesion* – facilitated through the *behaviour* of characters and objects – *presence* is likely achieved and the user believes she is transported into the VE.

In broad terms, this is the basic research theory about VR. If you have the terms marked with italics above clear in your mind, you should be able to navigate most of the research made in the last 15 years. It should also be significantly easier for you to think about and discuss VR in a precise manner.

### More practical design terms

Some HMD-producers have published best practice manuals, most of which are included in the literature overview at the end of this book. The following chapter of the book is an attempt to distill some general best practice advice. It is based most directly on the best practices published by Oculus, and is centred on the visual challenges of VR.

First off, it is important to understand the basic way the technology functions. An HMD renders to different images, sent through two lenses, each to one eye of the user. This is because one of the primary ways we see depth is through biocular – that is, “with two eyes” – phenomena. That means that because our eyes are placed in the way they are, we see two slightly different images of the world simultaneously, one for each eye. Our brain combines these two images to one stereoscopic image and thus creates a sense of depth. This is used by the HMD to create the feeling of depth in a virtual world.



Photo: <https://www.apkgplay.com/da/vr-player-pro>

The distance between the two images that are rendered should obviously be as close to the natural distance between our eyes as possible. This is achieved through placing two cameras instead of one in the engine that is used for rendering and then placing them at a proper distance to each other. The distance between two eyes is called interpupillary distance (IPD), mens afstanden imellem de to kameraer kaldes inter-camera distance (ICD). Finally, the distance should not be too far off from the distance between the two lenses in the HMD, which is called interaxial distance (IAD). The average IPD is 63,5 mm, which is also the IAD of the Oculus HMD. You can experiment with ICD, but it should probably not be below 52mm or above 78mm, since those are the two data outliers hiding behind the average of 63,5mm.

However, virtual worlds on a flat screen also have a sense of depth, and that is because not all perceptions of depth are biocular. Some are monocular – that is to say “with one eye” – best exemplified by perspective painting. When we see depth in a painting, it’s not because the painting



actually is deeper than the canvas, but because it facilitates a feeling of depth through techniques such as scale, systematic use of lines at certain angles and so on.

In the real world, we focus on things, animals and humans who are placed at different distances from ourselves through two techniques. Accommodation – where the lenses of our eyes physically focus like a camera lens – and vergence – which means that the eyes rotate closer to the nose to bring a certain depth plane into focus.

In VE accommodation is fixed – everything is already rendered as in-focus, unlike in movies where the camera lens is focused on certain parts of a situation.

Vergence, however, is still functioning and it is the primary way we focus while in VR. It turns out that it's pretty hard on the eyes to focus through vergence for longer periods of time, unless the person or object you are focusing on is inside a certain distance, namely between 0,75 metres and 3,5 metres, with 2,5 metres being the best choice.

The result of this is that most best practices caution against rendering UI-elements close to the camera, such as for example the guns carried in many first person shooters. This will simply be too uncomfortable for longer periods of time. Experimenting with ways to place the UI in the VE is one of the most often undertaken activities of VR-developers at the moment. an lægger UI ud i VE, sådan så man får informationerne på behørig afstand.

There are many more best practices, especially when it comes to combating simulation sickness, but the above should help you navigate through them with ease.

## Test of functionality and user experience in VR

The development of VR-experiences provides certain challenges when compared to the software development set-up. Where most development environments work with a relatively quick test-cycle for functionality and basic user experience – that is to say that new code implementation can quickly be compiled and run – it is more complicated when working with VR.

The reason for this is that while you can easily run a VR-experience in a window on a screen, the window has difficulty showing the entirety of the FOV available to the user at any given time. Thus a user oftentimes reacts to parts of the VE that are simply not present on the screen, making it difficult to design effectively.

This means that there is a lot of experiments being run to determine how to develop effectively and quickly with a reasonably fast test-cycle in VR.

The closest you get to the normal way of going through the test is to let the developer who has written or corrected the code don an HMD herself and go through the test. This tends to result in a slow process, however, wpecially in situations where effects of relatively small alterations need to be tested. The developer must:

1. Implement the changes in the code
2. Don the HMD
3. Adjust the HMD so it is showing the experience well
4. Run the test
5. Remove the HMD
6. Note the test results
7. React to the test results in the next implementation

In a situation where 10-15 small adjustments must be made to achieve the right result – not an uncommon situation, especially in game development – the 7 steps is quite a mouthful.

VR-developers have consequently experimented with setting up a variety of physical test-environments, typically assigning the different 7 steps to different persons. The most popular role configuration as of this writing seems to be using three persons – a programmer, a main tester and an HMD-user. Having a dedicated HMD-user gets rid of points 2, 3 and 5 above. A test using these three roles would look something like this:

<b>Programmer</b>	<b>Main tester</b>	<b>HMD-user</b>
Implement the changes in the code		
		Run the test
	Note the results of the test	
React to the test results in the next implementation		

If you combine this approach to testing with other system development methodologies – for example Kent Brock’s eXtreme Programming, where the main tester and the programmer can be in a pair programming relationship, while an on-site customer can be the HMD-user – you can achieve a very effective, iterative approach to development.

The iterative approach to development of software is especially essential for game development. And since VR has a lot in common with digital games, perhaps more than other classical flat screen applications, it is reasonable to ensure a systems development and test technique that incorporates this practice.

There is still no actual consensus about how to do VR development, but approaches like these seem to point the way.

## The market for Virtual Reality

The Consumer market for VR has long been predicted to open up in 2016, but even though the market has grown steadily all through the year, explosive growth has eluded it.

Here is a run-down of the collected installation base that represents the best guess of business analytics as of the tail end of 2016:

- Oculus Rift: 355,000
- HTC Vive: 420,000
- Samsung Gear VR: 2,3 millions
- PS VR: 745,000
- Daydream: 261,000
- Google Cardboard: 88,4 millions

This means that the collected installation base of VR (other than Cardboard) is 4,081,000 units. In comparison, PlayStation 4 has an installation base of 53 million units.

At the same time there is still great differences in developing for the different platforms. Behind the 88,4 million Google Cardboard HMDs lies support for more than 4000 different phones, which makes effective development for the platform a tricky proposition, especially when you work with games. The Cardboard seem to be a better fit for companies working with 360 video.

The different input devices for Vive, Rift and PS VR make cross-platform development in the high-end field difficult. Khronos are working on establishing a standard to solve this, but it is reasonable to assume that this will not materialise until late 2019 at the earliest.

At this moment in time – January 2017 – the most promising platform seems to be Samsung Gear VR, which is developed by Oculus and has a uniform store back-end. In 2017, Daydream could become a rival once more phones are supported, as long as a certain focus is kept. The main advantage of these platforms is that they balance a reasonably large user base with a limited set of supported hardware specs – at least Daydream promises this.

There are many different reasons that one could point to to explain the lack of an installation base, but the most prevalent analysis in the tech industry seems to be:

1. Very little installation base for the necessary hardware for the best solutions (high-end gaming PC)
2. No killer app
3. VR is a highly specialised function, which as a consumer you cannot justify as much else than a pure entertainment purchase – and in light of that, most solutions are still too expensive.

It must be said that in 2016 there were around 16 million users of VR, driving a revenue generation in the field of 2,7 billion dollars. This seems to indicate that VR has a grip on the same

kind of core audience that made up the success of Apple in the 2000s and early 2010s – innovators who are willing to spend money.

Hidden behind the direct consumer market a host of B2B markets are growing. The company Force Field for example, develop both games and VR based advertisements, while IT-giant SAP has an entire division dedicated to charting possible business uses of VR. This may represent another field where the expertise of game developers can come in quite handy.



### Literature:

The following sources represent a sampling of a much, much larger collection of literature and videos. They function as a primer intended to bring you up to speed on VR in a scientific, conceptual and business context. As such, they are representative, but not by any means exhausting.

### Fiction:

The first description of VR was made in 1935 by S. G. Weinbaum. The text is only a few pages long, but it charts out quite clearly the promises and challenges VR faces even today.

Weinbaum, S. G. (1935) : *Pygmalion's Spectacles* (<http://www.gutenberg.org/files/22893/22893-h/22893-h.htm>)

In addition, the following three books are very well worth your time for some conceptual looks at VR that seems to be influential in the business.

Gibson, William (1984): *Neuromancer*

Scalzi, John (2014): *Lock In*

Stephenson, Neal (1992): *Snow Crash*

### Scientific articles:

Freina, Laura og Michela Ott: A Literature Review on Immersive Virtual Reality in Education (<http://www.itd.cnr.it/download/eLSE%202015%20Freina%20Ott%20Paper.pdf>)

Usoh, Martin, Catena, Ernest, Arman, Sima og Slater, Mel: Using Presence Questionnaires in Reality (<http://www.cise.ufl.edu/research/lok/teaching/ve-s09/papers/questionnaire-paper.pdf>)

Sanchez-Vives, Maria V.: From presence to consciousness through virtual reality ([http://wexler.free.fr/library/files/sanchez-vives%20\(2005\)%20from%20presence%20to%20consciousness%20through%20virtual%20reality.pdf](http://wexler.free.fr/library/files/sanchez-vives%20(2005)%20from%20presence%20to%20consciousness%20through%20virtual%20reality.pdf))

Slater, Mel: Place Illusion and Plausibility Can Lead to Realistic Behaviour in Immersive Virtual Environments (<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.570.6644&rep=rep1&type=pdf>)

Slater, Mel og Wilbut, Sylvia: A Framework For Immersive Virtual Environments (FIVE): *Speculations on the Role of Presence in Virtual Environments* (<https://pdfs.semanticscholar.org/d366/7d18e85172c3db867782bcb1599d38e8202e.pdf>)

Witmer, Bob G og Michael J. Singer: *Measuring Presence in Virtual Environments: A Presence Questionnaire* (<https://nil.cs.uno.edu/publications/papers/witmer1998measuring.pdf>)

Witmer, Bob G, Jerome, Christian J. og Singer, Michael J.: *The Factor Structure of the Presence Questionnaire* (<https://www.researchgate.net/file.PostFileLoader.html?id=56ec634193553b245a0a9841&assetKey=AS%3A341085302870016%401458332481162>)

Og her er en lidt gammel (2004), men alligevel brugbar oversigt over forskellige måder at måle Presence på: <http://www8.informatik.umu.se/~jwworth/PresenceMeasurement.pdf>

Best Practice documents:

Crytek: Oculus (<http://docs.cryengine.com/display/SDKDOC4/VR+-+Oculus+Rift>)  
Crytek: Vive Support (<http://docs.cryengine.com/display/CEPROG/VR+-+HTC+Vive>)  
Oculus: *Best Practices* (<https://static.oculus.com/documentation/pdfs/intro-vr/latest/bp.pdf>)  
Oculus: Documentation (<https://developer3.oculus.com/documentation/pcsdk/latest/>)  
OSVR: Open Source VR Documentation (<https://github.com/OSVR/OSVR-Docs/blob/master/README.md>)  
Unity: VR Overview (<https://docs.unity3d.com/Manual/VROverview.html>)  
Unity: VR Reading List (<https://unity3d.com/learn/tutorials/topics/virtual-reality/vr-reading-list>)  
Unreal: Steam VR Best Practices  
(<https://docs.unrealengine.com/latest/INT/Platforms/SteamVR/BestPractices/>)  
Unreal: Virtual Reality Best Practices  
(<https://docs.unrealengine.com/latest/INT/Platforms/VR/ContentSetup/>)

Podcasts:

There is only one really worthwhile dedicated VR-podcast, namely Voices of VR. Fortunately, it has produced literally hundreds of episodes and a new one every three or four days. On this top 10 list, number 1, 2, 4, 5, 6 and 7 are well worth your time: <http://voicesofvr.com/top-10-voices-of-vr-episodes-to-get-started-into-vr/> and in conjunction, they give a good grounding in VR. Other than that, here's a sampling of more recent episodes, whose content can be gleaned from their URLs:

<http://voicesofvr.com/478-vr-fidelity-contract-cultivating-plausibility-presence-in-vr/>  
<http://voicesofvr.com/477-top-50-vr-storytelling-interviews-oculus-story-studio-roundtable-discussion/>  
<http://voicesofvr.com/designing-google-earth-vr-the-overview-effect-finding-common-ground/>  
<http://voicesofvr.com/473-can-vr-bridge-the-culture-gap-counter-cultural-indoctrination/>  
<http://voicesofvr.com/469-embodied-cognition-using-social-structures-for-collaborative-learning/>  
<http://voicesofvr.com/460-robo-recall-design-insights-from-epic-games-developers/>  
<http://voicesofvr.com/451-lessons-for-marketing-vr-experiences-from-mobile-app-store-optimization/>

Videos:

Alger, Mike: *VR Interface Design Manifesto*: (<https://www.youtube.com/watch?v=n3b8hZ5NV2E>)  
Alger, Mike: *VR Interface Design Pre-Visualisation Methods* (<https://www.youtube.com/watch?v=id86HeV-Vb8&t=0s>)  
VR Days Europe: Interview with Andrew Curtis (<https://www.youtube.com/watch?v=G3d5jIKJRM>)  
VR Days Europe: Interview with Dominic Eskofier (NVIDIA)  
(<https://www.youtube.com/watch?v=DzYQ83ioM3w>)  
VR Days Europe: Interview with Edward Miller (<https://www.youtube.com/watch?v=hV1vF8MLD5g>)  
VR Days Europe: Interview with Ela Darling (<https://www.youtube.com/watch?v=9LTPpEpFCDU>)

Websites:

The websites linked below are partly resources (Slater, Ux of VR og VR Wiki) and partly news sites. They are all useful.

Mel Slater's blog: <http://presence-thoughts.blogspot.dk>  
Road to VR: <http://www.roadtovr.com>  
*The UX of VR website*, <http://www.uxofvr.com>

VR Today Magazine: <https://vrtodaymagazine.com>  
VR Wiki: <https://vrwiki.wikispaces.com>

A few non-scientific articles:

Batchelor, James: *Virtual Reality Needs To Find Its Own Voice*,  
<http://www.gamesindustry.biz/articles/2016-11-28-virtual-reality-needs-to-find-its-own-voice>

Brightman, James: *VR the Biggest Loser This Holiday?:*

<http://www.gamesindustry.biz/articles/2016-11-29-vr-the-biggest-loser-this-holiday>

Litt, Michael: *Why I Can't Wait to Work in VR:* <https://www.fastcompany.com/3066611/the-future-of-work/why-i-cant-wait-to-work-in-vr>

Searles, Rebecca: *Virtual Reality Can Leave You With an Existential Hangover:*

[https://www.theatlantic.com/technology/archive/2016/12/post-vr-sadness/511232/?platform=hootsuite&utm\\_source=fbb](https://www.theatlantic.com/technology/archive/2016/12/post-vr-sadness/511232/?platform=hootsuite&utm_source=fbb)

Books:

In general, you seem to be better off with shorter sources than full-blown books at the moment, since the field is still coming into its own. However, *Infinite Reality* collects an impressive amount of experiments and theories, providing a good grounding in the basic scientific understanding of how virtual worlds work socially and cognitively. There is a newer version, which has not been surveyed for this report.

Bailenson, Jeremy and Blasovich, Jim (2011): *Infinite Reality: Avatars, Eternal Life, New Worlds, and the Dawn of the Virtual Revolution*, HarperCollins

## Appendix: Pygmalion's Spectacles

### PYGMALION'S SPECTACLES

*Af Stanley Graumann Weinbaum*

"But what is reality?" asked the gnomelike man. He gestured at the tall banks of buildings that loomed around Central Park, with their countless windows glowing like the cave fires of a city of Cro-Magnon people. "All is dream, all is illusion; I am your vision as you are mine."

Dan Burke, struggling for clarity of thought through the fumes of liquor, stared without comprehension at the tiny figure of his companion. He began to regret the impulse that had driven him to leave the party to seek fresh air in the park, and to fall by chance into the company of this diminutive old madman. But he had needed escape; this was one party too many, and not even the presence of Claire with her trim ankles could hold him there. He felt an angry desire to go home—not to his hotel, but home to Chicago and to the comparative peace of the Board of Trade. But he was leaving tomorrow anyway.

"You drink," said the elfin, bearded face, "to make real a dream. Is it not so? Either to dream that what you seek is yours, or else to dream that what you hate is conquered. You drink to escape reality, and the irony is that even reality is a dream."

"Cracked!" thought Dan again.

"Or so," concluded the other, "says the philosopher Berkeley."

"Berkeley?" echoed Dan. His head was clearing; memories of a Sophomore course in Elementary Philosophy drifted back. "Bishop Berkeley, eh?"

"You know him, then? The philosopher of Idealism—no?—the one who argues that we do not see, feel, hear, taste the object, but that we have only the sensation of seeing, feeling, hearing, tasting."

"I—sort of recall it."

"Hah! But sensations are *mental* phenomena. They exist in our minds. How, then, do we know that the objects themselves do not exist only in our minds?" He waved again at the light-flecked buildings. "You do not see that wall of masonry; you perceive only a *sensation*, a feeling of sight. The rest you interpret."

"You see the same thing," retorted Dan.

"How do you know I do? Even if you knew that what I call red would not be green could you see through my eyes—even if you knew that, how do you know that I too am not a dream of yours?" Dan laughed. "Of course nobody *knows* anything. You just get what information you can through the windows of your five senses, and then make your guesses. When they're wrong, you pay the

penalty." His mind was clear now save for a mild headache. "Listen," he said suddenly. "You can argue a reality away to an illusion; that's easy. But if your friend Berkeley is right, why can't you take a dream and make it real? If it works one way, it must work the other."

The beard waggled; elf-bright eyes glittered queerly at him. "All artists do that," said the old man softly. Dan felt that something more quivered on the verge of utterance.

"That's an evasion," he grunted. "Anybody can tell the difference between a picture and the real thing, or between a movie and life."

"But," whispered the other, "the realer the better, no? And if one could make a—a movie—*very* real indeed, what would you say then?"

"Nobody can, though."

The eyes glittered strangely again. "I can!" he whispered. "I *did*!"

"Did what?"

"Made real a dream." The voice turned angry. "Fools! I bring it here to sell to Westman, the camera people, and what do they say? 'It isn't clear. Only one person can use it at a time. It's too expensive.' Fools! Fools!"

"Huh?"

"Listen! I'm Albert Ludwig—*Professor* Ludwig." As Dan was silent, he continued, "It means nothing to you, eh? But listen—a movie that gives one sight and sound. Suppose now I add taste, smell, even touch, if your interest is taken by the story. Suppose I make it so that you are in the story, you speak to the shadows, and the shadows reply, and instead of being on a screen, the story is all about you, and you are in it. Would that be to make real a dream?"

"How the devil could you do that?"

"How? How? But simply! First my liquid positive, then my magic spectacles. I photograph the story in a liquid with light-sensitive chromates. I build up a complex solution—do you see? I add taste chemically and sound electrically. And when the story is recorded, then I put the solution in my spectacle—my movie projector. I electrolyze the solution, break it down; the older chromates go first, and out comes the story, sight, sound, smell, taste—all!"

"Touch?"

"If your interest is taken, your mind supplies that." Eagerness crept into his voice. "You will look at it, Mr.—?"



"Burke," said Dan. "A swindle!" he thought. Then a spark of recklessness glowed out of the vanishing fumes of alcohol. "Why not?" he grunted.

He rose; Ludwig, standing, came scarcely to his shoulder. A queer gnomelike old man, Dan thought as he followed him across the park and into one of the scores of apartment hotels in the vicinity. In his room Ludwig fumbled in a bag, producing a device vaguely reminiscent of a gas mask. There were goggles and a rubber mouthpiece; Dan examined it curiously, while the little bearded professor brandished a bottle of watery liquid.

"Here it is!" he gloated. "My liquid positive, the story. Hard photography—infernally hard, therefore the simplest story. A Utopia—just two characters and you, the audience. Now, put the spectacles on. Put them on and tell me what fools the Westman people are!" He decanted some of the liquid into the mask, and trailed a twisted wire to a device on the table. "A rectifier," he explained. "For the electrolysis."

"Must you use all the liquid?" asked Dan. "If you use part, do you see only part of the story? And which part?"

"Every drop has all of it, but you must fill the eye-pieces." Then as Dan slipped the device gingerly on, "So! Now what do you see?"

"Not a damn thing. Just the windows and the lights across the street."

"Of course. But now I start the electrolysis. Now!"

There was a moment of chaos. The liquid before Dan's eyes clouded suddenly white, and formless sounds buzzed. He moved to tear the device from his head, but emerging forms in the mistiness caught his interest. Giant things were writhing there.

The scene steadied; the whiteness was dissipating like mist in summer. Unbelieving, still gripping the arms of that unseen chair, he was staring at a forest. But what a forest! Incredible, unearthly, beautiful! Smooth boles ascended inconceivably toward a brightening sky, trees bizarre as the forests of the Carboniferous age. Infinitely overhead swayed misty fronds, and the verdure showed brown and green in the heights. And there were birds—at least, curiously lovely pipings and twitterings were all about him though he saw no creatures—thin elfin whistlings like fairy bugles sounded softly.

He sat frozen, entranced. A louder fragment of melody drifted down to him, mounting in exquisite, ecstatic bursts, now clear as sounding metal, now soft as remembered music. For a moment he forgot the chair whose arms he gripped, the miserable hotel room invisibly about him, old Ludwig, his aching head. He imagined himself alone in the midst of that lovely glade. "Eden!" he muttered, and the swelling music of unseen voices answered.

Some measure of reason returned. "Illusion!" he told himself. Clever optical devices, not reality. He groped for the chair's arm, found it, and clung to it; he scraped his feet and found again an

inconsistency. To his eyes the ground was mossy verdure; to his touch it was merely a thin hotel carpet.

The elfin buglings sounded gently. A faint, deliciously sweet perfume breathed against him; he glanced up to watch the opening of a great crimson blossom on the nearest tree, and a tiny reddish sun edged into the circle of sky above him. The fairy orchestra swelled louder in its light, and the notes sent a thrill of wistfulness through him. Illusion? If it were, it made reality almost unbearable; he wanted to believe that somewhere—somewhere this side of dreams, there actually existed this region of loveliness. An outpost of Paradise? Perhaps.

And then—far through the softening mists, he caught a movement that was not the swaying of verdure, a shimmer of silver more solid than mist. Something approached. He watched the figure as it moved, now visible, now hidden by trees; very soon he perceived that it was human, but it was almost upon him before he realized that it was a girl.

She wore a robe of silvery, half-translucent stuff, luminous as starbeams; a thin band of silver bound glowing black hair about her forehead, and other garment or ornament she had none. Her tiny white feet were bare to the mossy forest floor as she stood no more than a pace from him, staring dark-eyed. The thin music sounded again; she smiled.

Dan summoned stumbling thoughts. Was this being also—illusion? Had she no more reality than the loveliness of the forest? He opened his lips to speak, but a strained excited voice sounded in his ears. "Who are you?" Had he spoken? The voice had come as if from another, like the sound of one's words in fever.

The girl smiled again. "English!" she said in queer soft tones. "I can speak a little English." She spoke slowly, carefully. "I learned it from"—she hesitated—"my mother's father, whom they call the Grey Weaver."

Again came the voice in Dan's ears. "Who are you?"

"I am called Galatea," she said. "I came to find you."

"To find me?" echoed the voice that was Dan's.

"Leucon, who is called the Grey Weaver, told me," she explained smiling. "He said you will stay with us until the second noon from this." She cast a quick slanting glance at the pale sun now full above the clearing, then stepped closer. "What are you called?"

"Dan," he muttered. His voice sounded oddly different.

"What a strange name!" said the girl. She stretched out her bare arm. "Come," she smiled.

Dan touched her extended hand, feeling without any surprise the living warmth of her fingers. He had forgotten the paradoxes of illusion; this was no longer illusion to him, but reality itself. It seemed to him that he followed her, walking over the shadowed turf that gave with springy crunch beneath his tread, though Galatea left hardly an imprint. He glanced down, noting that he himself wore a silver garment, and that his feet were bare; with the glance he felt a feathery breeze on his body and a sense of mossy earth on his feet.

"Galatea," said his voice. "Galatea, what place is this? What language do you speak?"

She glanced back laughing. "Why, this is Paracosma, of course, and this is our language."

"Paracosma," muttered Dan. "Para—cosma!" A fragment of Greek that had survived somehow from a Sophomore course a decade in the past came strangely back to him. Paracosma! Land-beyond-the-world!

Galatea cast a smiling glance at him. "Does the real world seem strange," she queried, "after that shadow land of yours?"

"Shadow land?" echoed Dan, bewildered. "*This* is shadow, not my world."

The girl's smile turned quizzical. "Poof!" she retorted with an impudently lovely pout. "And I suppose, then, that *I* am the phantom instead of you!" She laughed. "Do I seem ghostlike?"

Dan made no reply; he was puzzling over unanswerable questions as he trod behind the lithe figure of his guide. The aisle between the unearthly trees widened, and the giants were fewer. It seemed a mile, perhaps, before a sound of tinkling water obscured that other strange music; they emerged on the bank of a little river, swift and crystalline, that rippled and gurgled its way from glowing pool to flashing rapids, sparkling under the pale sun. Galatea bent over the brink and cupped her hands, raising a few mouthfuls of water to her lips; Dan followed her example, finding the liquid stinging cold.

"How do we cross?" he asked.

"You can wade up there,"—the dryad who led him gestured to a sun-lit shallows above a tiny falls—"but I always cross here." She poised herself for a moment on the green bank, then dove like a silver arrow into the pool. Dan followed; the water stung his body like champagne, but a stroke or two carried him across to where Galatea had already emerged with a glistening of creamy bare limbs. Her garment clung tight as a metal sheath to her wet body; he felt a breath-taking thrill at the sight of her. And then, miraculously, the silver cloth was dry, the droplets rolled off as if from oiled silk, and they moved briskly on.

The incredible forest had ended with the river; they walked over a meadow studded with little, many-hued, star-shaped flowers, whose fronds underfoot were soft as a lawn. Yet still the sweet pipings followed them, now loud, now whisper-soft, in a tenuous web of melody.

"Galatea!" said Dan suddenly. "Where is the music coming from?"

She looked back amazed. "You silly one!" she laughed. "From the flowers, of course. See!" she plucked a purple star and held it to his ear; true enough, a faint and plaintive melody hummed out of the blossom. She tossed it in his startled face and skipped on.

A little copse appeared ahead, not of the gigantic forest trees, but of lesser growths, bearing flowers and fruits of iridescent colors, and a tiny brook bubbled through. And there stood the objective of their journey—a building of white, marble-like stone, single-storied and vine covered, with broad glassless windows. They trod upon a path of bright pebbles to the arched entrance, and here, on an intricate stone bench, sat a grey-bearded patriarchal individual. Galatea addressed him in a liquid language that reminded Dan of the flower-pipings; then she turned. "This is Leucon," she said, as the ancient rose from his seat and spoke in English.

"We are happy, Galatea and I, to welcome you, since visitors are a rare pleasure here, and those from your shadowy country most rare."

Dan uttered puzzled words of thanks, and the old man nodded, reseating himself on the carved bench; Galatea skipped through the arched entrance, and Dan, after an irresolute moment, dropped to the remaining bench. Once more his thoughts were whirling in perplexed turbulence. Was all this indeed but illusion? Was he sitting, in actuality, in a prosaic hotel room, peering through magic spectacles that pictured this world about him, or was he, transported by some miracle, really sitting here in this land of loveliness? He touched the bench; stone, hard and unyielding, met his fingers.

"Leucon," said his voice, "how did you know I was coming?"

"I was told," said the other.

"By whom?"

"By no one."

"Why—*someone* must have told you!"

The Grey Weaver shook his solemn head. "I was just told."

Dan ceased his questioning, content for the moment to drink in the beauty about him and then Galatea returned bearing a crystal bowl of the strange fruits. They were piled in colorful disorder, red, purple, orange and yellow, pear-shaped, egg-shaped, and clustered spheroids—fantastic, unearthly. He selected a pale, transparent ovoid, bit into it, and was deluged by a flood of sweet liquid, to the amusement of the girl. She laughed and chose a similar morsel; biting a tiny puncture in the end, she squeezed the contents into her mouth. Dan took a different sort, purple and tart as Rhenish wine, and then another, filled with edible, almond-like seeds. Galatea laughed delightedly

at his surprises, and even Leucon smiled a grey smile. Finally Dan tossed the last husk into the brook beside them, where it danced briskly toward the river.

"Galatea," he said, "do you ever go to a city? What cities are in Paracosma?"

"Cities? What are cities?"

"Places where many people live close together."

"Oh," said the girl frowning. "No. There are no cities here."

"Then where are the people of Paracosma? You must have neighbors."

The girl looked puzzled. "A man and a woman live off there," she said, gesturing toward a distant blue range of hills dim on the horizon. "Far away over there. I went there once, but Leucon and I prefer the valley."

"But Galatea!" protested Dan. "Are you and Leucon alone in this valley? Where—what happened to your parents—your father and mother?"

"They went away. That way—toward the sunrise. They'll return some day."

"And if they don't?"

"Why, foolish one! What could hinder them?"

"Wild beasts," said Dan. "Poisonous insects, disease, flood, storm, lawless people, death!"

"I never heard those words," said Galatea. "There are no such things here." She sniffed contemptuously. "Lawless people!"

"Not—death?"

"What is death?"

"It's—" Dan paused helplessly. "It's like falling asleep and never waking. It's what happens to everyone at the end of life."

"I never heard of such a thing as the end of life!" said the girl decidedly. "There isn't such a thing."

"What happens, then," queried Dan desperately, "when one grows old?"

"Nothing, silly! No one grows old unless he wants to, like Leucon. A person grows to the age he likes best and then stops. It's a law!"



Dan gathered his chaotic thoughts. He stared into Galatea's dark, lovely eyes. "Have you stopped yet?"

The dark eyes dropped; he was amazed to see a deep, embarrassed flush spread over her cheeks. She looked at Leucon nodding reflectively on his bench, then back to Dan, meeting his gaze.

"Not yet," he said.

"And when will you, Galatea?"

"When I have had the one child permitted me. You see"—she stared down at her dainty toes—"one cannot—bear children—afterwards."

"Permitted? Permitted by whom?"

"By a law."

"Laws! Is everything here governed by laws? What of chance and accidents?"

"What are those—chance and accidents?"

"Things unexpected—things unforeseen."

"Nothing is unforeseen," said Galatea, still soberly. She repeated slowly, "Nothing is unforeseen." He fancied her voice was wistful.

Leucon looked up. "Enough of this," he said abruptly. He turned to Dan, "I know these words of yours—chance, disease, death. They are not for Paracosma. Keep them in your unreal country."

"Where did you hear them, then?"

"From Galatea's mother," said the Grey Weaver, "who had them from your predecessor—a phantom who visited here before Galatea was born."

Dan had a vision of Ludwig's face. "What was he like?"

"Much like you."

"But his name?"

The old man's mouth was suddenly grim. "We do not speak of him," he said and rose, entering the dwelling in cold silence.

"He goes to weave," said Galatea after a moment. Her lovely, piquant face was still troubled.

"What does he weave?"

"This," She fingered the silver cloth of her gown. "He weaves it out of metal bars on a very clever machine. I do not know the method."

"Who made the machine?"

"It was here."

"But—Galatea! Who built the house? Who planted these fruit trees?"

"They were here. The house and trees were always here." She lifted her eyes. "I told you everything had been foreseen, from the beginning until eternity—everything. The house and trees and machine were ready for Leucon and my parents and me. There is a place for my child, who will be a girl, and a place for her child—and so on forever."

Dan thought a moment. "Were you born here?"

"I don't know." He noted in sudden concern that her eyes were glistening with tears.

"Galatea, dear! Why are you unhappy? What's wrong?"

"Why, nothing!" She shook her black curls, smiled suddenly at him. "What could be wrong? How can one be unhappy in Paracosma?" She sprang erect and seized his hand. "Come! Let's gather fruit for tomorrow."

She darted off in a whirl of flashing silver, and Dan followed her around the wing of the edifice. Graceful as a dancer she leaped for a branch above her head, caught it laughingly, and tossed a great golden globe to him. She loaded his arms with the bright prizes and sent him back to the bench, and when he returned, she piled it so full of fruit that a deluge of colorful spheres dropped around him. She laughed again, and sent them spinning into the brook with thrusts of her rosy toes, while Dan watched her with an aching wistfulness. Then suddenly she was facing him; for a long, tense instant they stood motionless, eyes upon eyes, and then she turned away and walked slowly around to the arched portal. He followed her with his burden of fruit; his mind was once more in a turmoil of doubt and perplexity.

The little sun was losing itself behind the trees of that colossal forest to the west, and a coolness stirred among long shadows. The brook was purple-hued in the dusk, but its cheery notes mingled still with the flower music. Then the sun was hidden; the shadow fingers darkened the meadow; of a sudden the flowers were still, and the brook gurgled alone in a world of silence. In silence too, Dan entered the doorway.

The chamber within was a spacious one, floored with large black and white squares; exquisite benches of carved marble were here and there. Old Leucon, in a far corner, bent over an intricate, glistening mechanism, and as Dan entered he drew a shining length of silver cloth from it, folded

it, and placed it carefully aside. There was a curious, unearthly fact that Dan noted; despite windows open to the evening, no night insects circled the globes that glowed at intervals from niches in the walls.

Galatea stood in a doorway to his left, leaning half-wearily against the frame; he placed the bowl of fruit on a bench at the entrance and moved to her side.

"This is yours," she said, indicating the room beyond. He looked in upon a pleasant, smaller chamber; a window framed a starry square, and a thin, swift, nearly silent stream of water gushed from the mouth of a carved human head on the left wall, curving into a six-foot basin sunk in the floor. Another of the graceful benches covered with the silver cloth completed the furnishings; a single glowing sphere, pendant by a chain from the ceiling, illuminated the room. Dan turned to the girl, whose eyes were still unwontedly serious.

"This is ideal," he said, "but, Galatea, how am I to turn out the light?"

"Turn it out?" she said. "You must cap it—so!" A faint smile showed again on her lips as she dropped a metal covering over the shining sphere. They stood tense in the darkness; Dan sensed her nearness achingly, and then the light was on once more. She moved toward the door, and there paused, taking his hand.

"Dear shadow," she said softly, "I hope your dreams are music." She was gone.

Dan stood irresolute in his chamber; he glanced into the large room where Leucon still bent over his work, and the Grey Weaver raised a hand in a solemn salutation, but said nothing. He felt no urge for the old man's silent company and turned back into his room to prepare for slumber.

Almost instantly, it seemed, the dawn was upon him and bright elfin pipings were all about him, while the odd ruddy sun sent a broad slanting plane of light across the room. He rose as fully aware of his surroundings as if he had not slept at all; the pool tempted him and he bathed in stinging water. Thereafter he emerged into the central chamber, noting curiously that the globes still glowed in dim rivalry to the daylight. He touched one casually; it was cool as metal to his fingers, and lifted freely from its standard. For a moment he held the cold flaming thing in his hands, then replaced it and wandered into the dawn.

Galatea was dancing up the path, eating a strange fruit as rosy as her lips. She was merry again, once more the happy nymph who had greeted him, and she gave him a bright smile as he chose a sweet green ovoid for his breakfast.

"Come on!" she called. "To the river!"

She skipped away toward the unbelievable forest; Dan followed, marveling that her lithe speed was so easy a match for his stronger muscles. Then they were laughing in the pool, splashing about until Galatea drew herself to the bank, glowing and panting. He followed her as she lay

relaxed; strangely, he was neither tired nor breathless, with no sense of exertion. A question recurred to him, as yet unasked.

"Galatea," said his voice, "Whom will you take as mate?"

Her eyes went serious. "I don't know," she said. "At the proper time he will come. That is a law."

"And will you be happy?"

"Of course." She seemed troubled. "Isn't everyone happy?"

"Not where I live, Galatea."

"Then that must be a strange place—that ghostly world of yours. A rather terrible place."

"It is, often enough," Dan agreed. "I wish—" He paused. What did he wish? Was he not talking to an illusion, a dream, an apparition? He looked at the girl, at her glistening black hair, her eyes, her soft white skin, and then, for a tragic moment, he tried to feel the arms of that drab hotel chair beneath his hands—and failed. He smiled; he reached out his fingers to touch her bare arm, and for an instant she looked back at him with startled, sober eyes, and sprang to her feet.

"Come on! I want to show you my country." She set off down the stream, and Dan rose reluctantly to follow.

What a day that was! They traced the little river from still pool to singing rapids, and ever about them were the strange twitterings and pipings that were the voices of the flowers. Every turn brought a new vista of beauty; every moment brought a new sense of delight. They talked or were silent; when they were thirsty, the cool river was at hand; when they were hungry, fruit offered itself. When they were tired, there was always a deep pool and a mossy bank; and when they were rested, a new beauty beckoned. The incredible trees towered in numberless forms of fantasy, but on their own side of the river was still the flower-starred meadow. Galatea twisted him a bright-blossomed garland for his head, and thereafter he moved always with a sweet singing about him. But little by little the red sun slanted toward the forest, and the hours dripped away. It was Dan who pointed it out, and reluctantly they turned homeward.

As they returned, Galatea sang a strange song, plaintive and sweet as the medley of river and flower music. And again her eyes were sad.

"What song is that?" he asked.

"It is a song sung by another Galatea," she answered, "who is my mother." She laid her hand on his arm. "I will make it into English for you." She sang:

"The River lies in flower and fern,  
In flower and fern it breathes a song.

It breathes a song of your return,  
Of your return in years too long.  
In years too long its murmurs bring  
Its murmurs bring their vain replies,  
Their vain replies the flowers sing,  
The flowers sing, 'The River lies!'"

Her voice quavered on the final notes; there was silence save for the tinkle of water and the flower bugles. Dan said, "Galatea—" and paused. The girl was again somber-eyed, tearful. He said huskily, "That's a sad song, Galatea. Why was your mother sad? You said everyone was happy in Paracosma."

"She broke a law," replied the girl tonelessly. "It is the inevitable way to sorrow." She faced him. "She fell in love with a phantom!" Galatea said. "One of your shadowy race, who came and stayed and then had to go back. So when her appointed lover came, it was too late; do you understand? But she yielded finally to the law, and is forever unhappy, and goes wandering from place to place about the world." She paused. "I shall never break a law," she said defiantly.

Dan took her hand. "I would not have you unhappy, Galatea. I want you always happy."

She shook her head. "I *am* happy," she said, and smiled a tender, wistful smile.

They were silent a long time as they trudged the way homeward. The shadows of the forest giants reached out across the river as the sun slipped behind them. For a distance they walked hand in hand, but as they reached the path of pebbly brightness near the house, Galatea drew away and sped swiftly before him. Dan followed as quickly as he might; when he arrived, Leucon sat on his bench by the portal, and Galatea had paused on the threshold. She watched his approach with eyes in which he again fancied the glint of tears.

"I am very tired," she said, and slipped within.

Dan moved to follow, but the old man raised a staying hand.

"Friend from the shadows," he said, "will you hear me a moment?"

Dan paused, acquiesced, and dropped to the opposite bench. He felt a sense of foreboding; nothing pleasant awaited him.

"There is something to be said," Leucon continued, "and I say it without desire to pain you, if phantoms feel pain. It is this: Galatea loves you, though I think she has not yet realized it."

"I love her too," said Dan.

The Grey Weaver stared at him. "I do not understand. Substance, indeed, may love shadow, but how can shadow love substance?"

"I love her," insisted Dan.

"Then woe to both of you! For this is impossible in Paracosma; it is a confliction with the laws. Galatea's mate is appointed, perhaps even now approaching."

"Laws! Laws!" muttered Dan. "Whose laws are they? Not Galatea's nor mine!"

"But they are," said the Grey Weaver. "It is not for you nor for me to criticize them—though I yet wonder what power could annul them to permit your presence here!"

"I had no voice in your laws."

The old man peered at him in the dusk. "Has anyone, anywhere, a voice in the laws?" he queried.

"In my country we have," retorted Dan.

"Madness!" growled Leucon. "Man-made laws! Of what use are man-made laws with only man-made penalties, or none at all? If you shadows make a law that the wind shall blow only from the east, does the west wind obey it?"

"We do pass such laws," acknowledged Dan bitterly. "They may be stupid, but they're no more unjust than yours."

"Ours," said the Grey Weaver, "are the unalterable laws of the world, the laws of Nature. Violation is always unhappiness. I have seen it; I have known it in another, in Galatea's mother, though Galatea is stronger than she." He paused. "Now," he continued, "I ask only for mercy; your stay is short, and I ask that you do no more harm than is already done. Be merciful; give her no more to regret."

He rose and moved through the archway; when Dan followed a moment later, he was already removing a square of silver from his device in the corner. Dan turned silent and unhappy to his own chamber, where the jet of water tinkled faintly as a distant bell.

Again he rose at the glow of dawn, and again Galatea was before him, meeting him at the door with her bowl of fruit. She deposited her burden, giving him a wan little smile of greeting, and stood facing him as if waiting.

"Come with me, Galatea," he said.

"Where?"

"To the river bank. To talk."



They trudged in silence to the brink of Galatea's pool. Dan noted a subtle difference in the world about him; outlines were vague, the thin flower pipings less audible, and the very landscape was queerly unstable, shifting like smoke when he wasn't looking at it directly. And strangely, though he had brought the girl here to talk to her, he had now nothing to say, but sat in aching silence with his eyes on the loveliness of her face.

Galatea pointed at the red ascending sun. "So short a time," she said, "before you go back to your phantom world. I shall be sorry, very sorry." She touched his cheek with her fingers. "Dear shadow!"

"Suppose," said Dan huskily, "that I won't go. What if I won't leave here?" His voice grew fiercer. "I'll not go! I'm going to stay!"

The calm mournfulness of the girl's face checked him; he felt the irony of struggling against the inevitable progress of a dream. She spoke. "Had I the making of the laws, you should stay. But you can't, dear one. You can't!"

Forgotten now were the words of the Grey Weaver. "I love you, Galatea," he said.

"And I you," she whispered. "See, dearest shadow, how I break the same law my mother broke, and am glad to face the sorrow it will bring." She placed her hand tenderly over his. "Leucon is very wise and I am bound to obey him, but this is beyond his wisdom because he let himself grow old." She paused. "He let himself grow old," she repeated slowly. A strange light gleamed in her dark eyes as she turned suddenly to Dan.

"Dear one!" she said tensely. "That thing that happens to the old—that death of yours! What follows it?"

"What follows death?" he echoed. "Who knows?"

"But—" Her voice was quivering. "But one can't simply—vanish! There must be an awakening."

"Who knows?" said Dan again. "There are those who believe we wake to a happier world, but—" He shook his head hopelessly.

"It must be true! Oh, it must be!" Galatea cried. "There must be more for you than the mad world you speak of!" She leaned very close. "Suppose, dear," she said, "that when my appointed lover arrives, I send him away. Suppose I bear no child, but let myself grow old, older than Leucon, old until death. Would I join you in your happier world?"

"Galatea!" he cried distractedly. "Oh, my dearest—what a terrible thought!"

"More terrible than you know," she whispered, still very close to him. "It is more than violation of a law; it is rebellion! Everything is planned, everything was foreseen, except this; and if I bear no child, her place will be left unfilled, and the places of her children, and of *their* children, and so on

until some day the whole great plan of Paracosma fails of whatever its destiny was to be." Her whisper grew very faint and fearful. "It is destruction, but I love you more than I fear—death!"

Dan's arms were about her. "No, Galatea! No! Promise me!"

She murmured, "I can promise and then break my promise." She drew his head down; their lips touched, and he felt a fragrance and a taste like honey in her kiss. "At least," she breathed. "I can give you a name by which to love you. Philometros! Measure of my love!"

"A name?" muttered Dan. A fantastic idea shot through his mind—a way of proving to himself that all this was reality, and not just a page that any one could read who wore old Ludwig's magic spectacles. If Galatea would speak his name! Perhaps, he thought daringly, perhaps then he could stay! He thrust her away.

"Galatea!" he cried. "Do you remember my name?"

She nodded silently, her unhappy eyes on his.

"Then say it! Say it, dear!"

She stared at him dumbly, miserably, but made no sound.

"Say it, Galatea!" he pleaded desperately. "My name, dear—just my name!" Her mouth moved; she grew pale with effort and Dan could have sworn that his name trembled on her quivering lips, though no sound came.

At last she spoke. "I can't, dearest one! Oh, I can't! A law forbids it!" She stood suddenly erect, pallid as an ivory carving. "Leucon calls!" she said, and darted away. Dan followed along the pebbled path, but her speed was beyond his powers; at the portal he found only the Grey Weaver standing cold and stern. He raised his hand as Dan appeared.

"Your time is short," he said. "Go, thinking of the havoc you have done."

"Where's Galatea?" gasped Dan.

"I have sent her away." The old man blocked the entrance; for a moment Dan would have struck him aside, but something withheld him. He stared wildly about the meadow—there! A flash of silver beyond the river, at the edge of the forest. He turned and raced toward it, while motionless and cold the Grey Weaver watched him go.

"Galatea!" he called. "Galatea!"

He was over the river now, on the forest bank, running through columned vistas that whirled about him like mist. The world had gone cloudy; fine flakes danced like snow before his eyes;

Paracosma was dissolving around him. Through the chaos he fancied a glimpse of the girl, but closer approach left him still voicing his hopeless cry of "Galatea!"

After an endless time, he paused; something familiar about the spot struck him, and just as the red sun edged above him, he recognized the place—the very point at which he had entered Paracosma! A sense of futility overwhelmed him as for a moment he gazed at an unbelievable apparition—a dark window hung in midair before him through which glowed rows of electric lights. Ludwig's window!

It vanished. But the trees writhed and the sky darkened, and he swayed dizzily in turmoil. He realized suddenly that he was no longer standing, but sitting in the midst of the crazy glade, and his hands clutched something smooth and hard—the arms of that miserable hotel chair. Then at last he saw her, close before him—Galatea, with sorrow-stricken features, her tear-filled eyes on his. He made a terrific effort to rise, stood erect, and fell sprawling in a blaze of coruscating lights. He struggled to his knees; walls—Ludwig's room—encompassed him; he must have slipped from the chair. The magic spectacles lay before him, one lens splintered and spilling a fluid no longer water-clear, but white as milk.

"God!" he muttered. He felt shaken, sick, exhausted, with a bitter sense of bereavement, and his head ached fiercely. The room was drab, disgusting; he wanted to get out of it. He glanced automatically at his watch: four o'clock—he must have sat here nearly five hours. For the first time he noticed Ludwig's absence; he was glad of it and walked dully out of the door to an automatic elevator. There was no response to his ring; someone was using the thing. He walked three flights to the street and back to his own room.

In love with a vision! Worse—in love with a girl who had never lived, in a fantastic Utopia that was literally nowhere! He threw himself on his bed with a groan that was half a sob. He saw finally the implication of the name Galatea. Galatea—Pygmalion's statue, given life by Venus in the ancient Grecian myth. But *his* Galatea, warm and lovely and vital, must remain forever without the gift of life, since he was neither Pygmalion nor God.

He woke late in the morning, staring uncomprehendingly about for the fountain and pool of Paracosma. Slow comprehension dawned; how much—*how much*—of last night's experience had been real? How much was the product of alcohol? Or had old Ludwig been right, and was there no difference between reality and dream?

He changed his rumpled attire and wandered despondently to the street. He found Ludwig's hotel at last; inquiry revealed that the diminutive professor had checked out, leaving no forwarding address.

What of it? Even Ludwig couldn't give what he sought, a living Galatea. Dan was glad that he had disappeared; he hated the little professor. Professor? Hypnotists called themselves "professors." He dragged through a weary day and then a sleepless night back to Chicago.

It was mid-winter when he saw a suggestively tiny figure ahead of him in the Loop. Ludwig! Yet what use to hail him? His cry was automatic. "Professor Ludwig!"

The elfin figure turned, recognized him, smiled. They stepped into the shelter of a building.

"I'm sorry about your machine, Professor. I'd be glad to pay for the damage."

"*Ach*, that was nothing—a cracked glass. But you—have you been ill? You look much the worse."

"It's nothing," said Dan. "Your show was marvelous, Professor—marvelous! I'd have told you so, but you were gone when it ended."

Ludwig shrugged. "I went to the lobby for a cigar. Five hours with a wax dummy, you know!"

"It was marvelous!" repeated Dan.

"So real?" smiled the other. "Only because you co-operated, then. It takes self-hypnosis."

"It was real, all right," agreed Dan glumly. "I don't understand it—that strange beautiful country."

"The trees were club-mosses enlarged by a lens," said Ludwig. "All was trick photography, but stereoscopic, as I told you—three dimensional. The fruits were rubber; the house is a summer building on our campus—Northern University. And the voice was mine; you didn't speak at all, except your name at the first, and I left a blank for that. I played your part, you see; I went around with the photographic apparatus strapped on my head, to keep the viewpoint always that of the observer. See?" He grinned wryly. "Luckily I'm rather short, or you'd have seemed a giant."

"Wait a minute!" said Dan, his mind whirling. "You say you played my part. Then Galatea—is *she* real too?"

"Tea's real enough," said the Professor. "My niece, a senior at Northern, and likes dramatics. She helped me out with the thing. Why? Want to meet her?"

Dan answered vaguely, happily. An ache had vanished; a pain was eased. Paracosma was attainable at last!

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